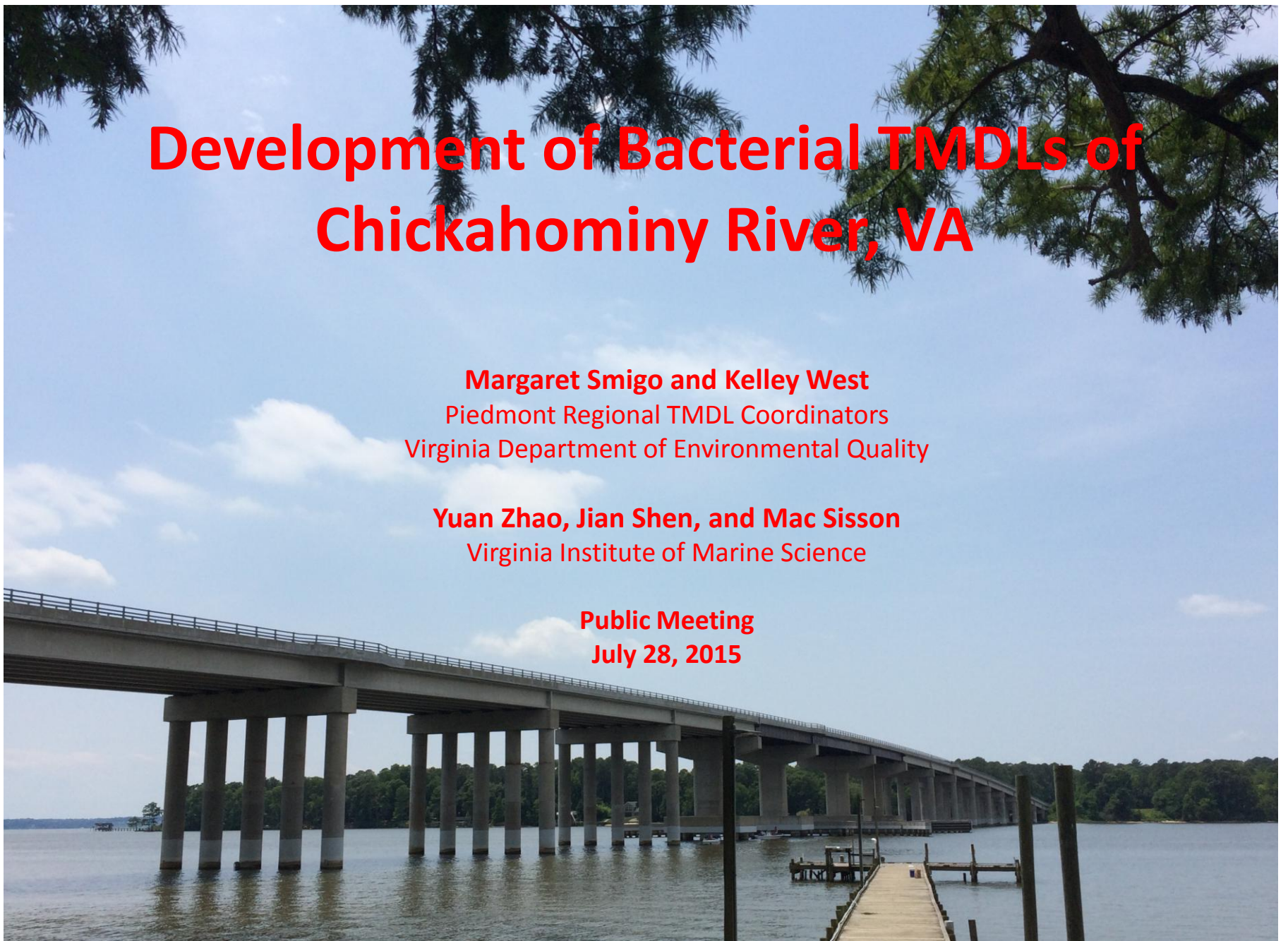


Development of Bacterial TMDLs of Chickahominy River, VA

Margaret Smigo and Kelley West
Piedmont Regional TMDL Coordinators
Virginia Department of Environmental Quality

Yuan Zhao, Jian Shen, and Mac Sisson
Virginia Institute of Marine Science

Public Meeting
July 28, 2015



Why We Are Here

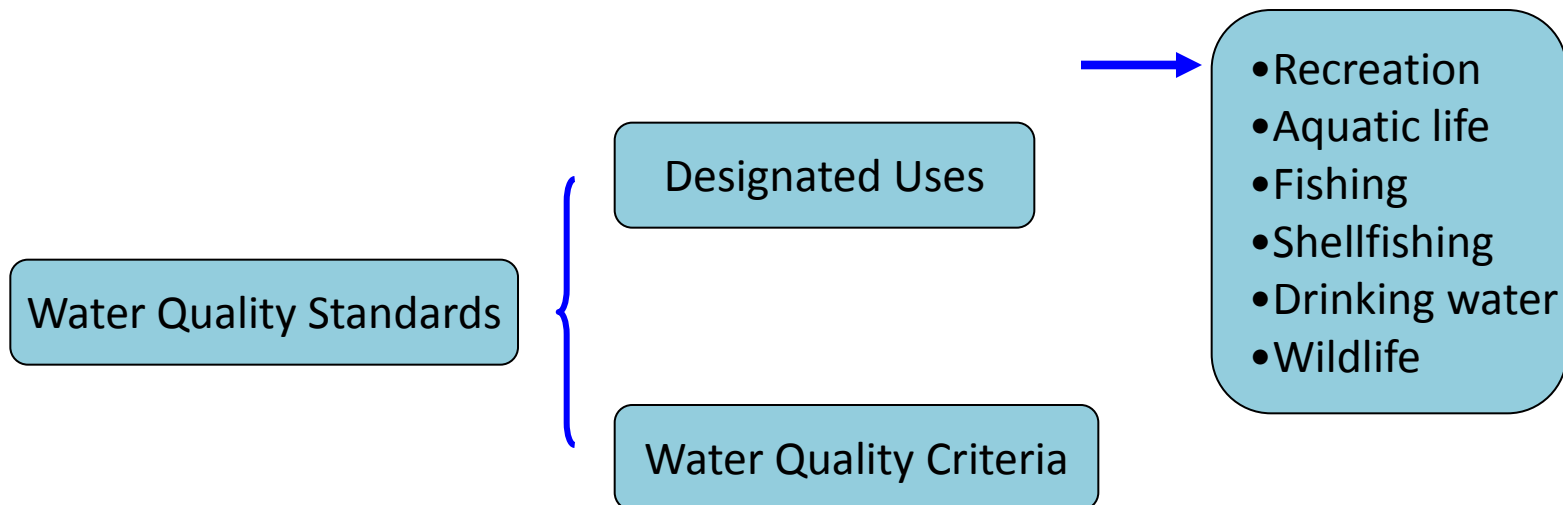
1. To learn about water quality of these creeks
2. To discuss the Total Maximum Daily Load (TMDL) development
3. To gather comments and encourage public participation

Outline

- The TMDL process
- Impaired waters and pollutants
- Procedures of pollutant source assessment
- Developed modeling approach
- Comments

The TMDL Process

- DEQ routinely monitors the quality of waters across the state and publishes a list of impaired waters every 2 years
- Virginia is required by law to establish a TMDL for each pollutant causing an impairment
- A TMDL is the amount of a particular pollutant that a stream can receive and still meet Water Quality Standards
- Water quality standards are regulations based on federal or state law that set numerical or narrative limits on pollutants



What is a TMDL ?

Total Maximum Daily Load

A TMDL is the amount of a particular pollutant that a stream can receive and still meet Water Quality Standards
AKA "Pollution Diet"

$$\text{TMDL} = \text{Sum of WLA} + \text{Sum of LA} + \text{MOS}$$

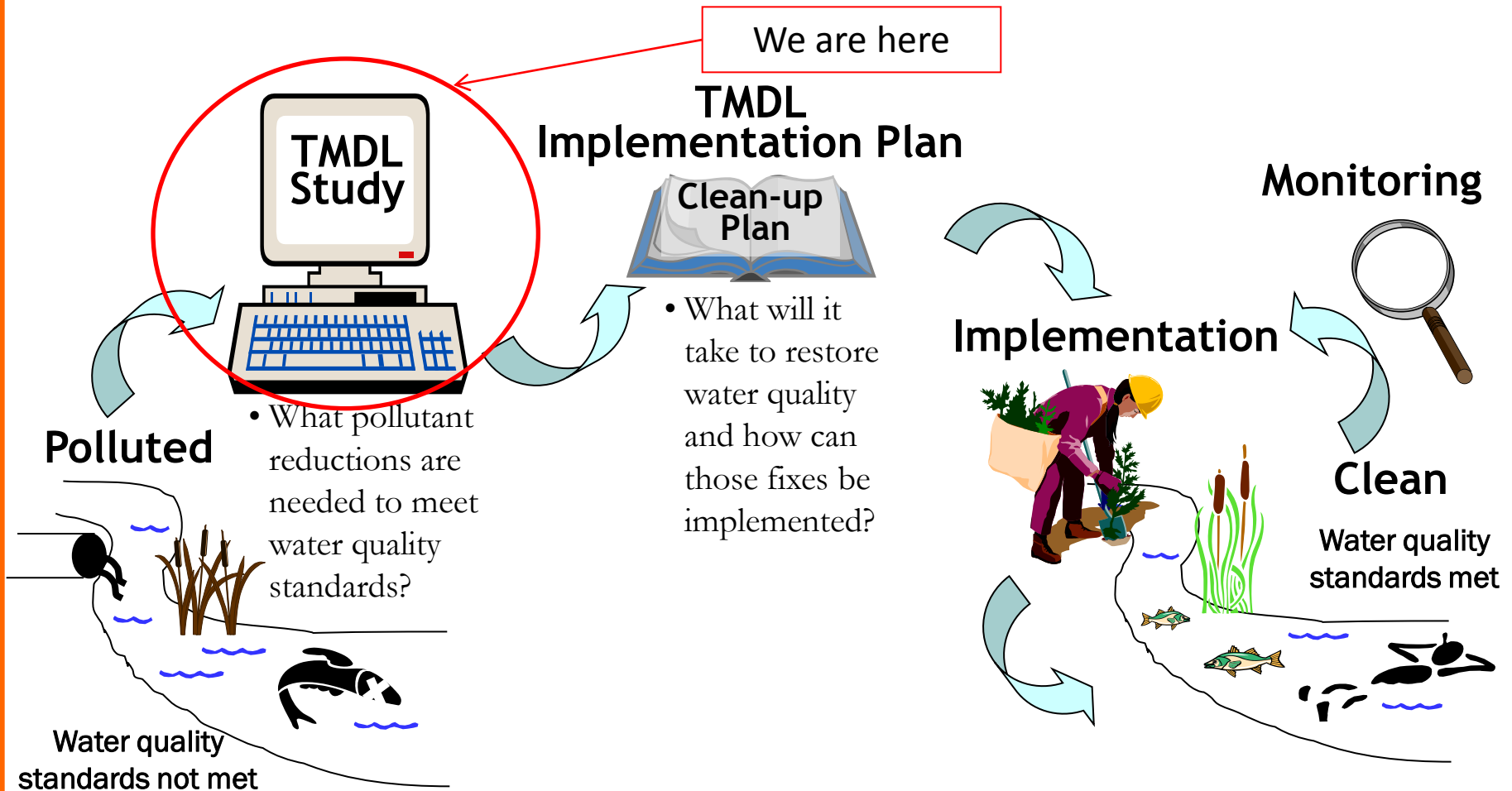
Where:

TMDL	=	Total Maximum Daily Load
WLA	=	Waste Load Allocation (point sources)
LA	=	Load Allocation (nonpoint sources)
MOS	=	Margin of Safety

Current Load = current loads discharged to the water body, which will be determined during this study

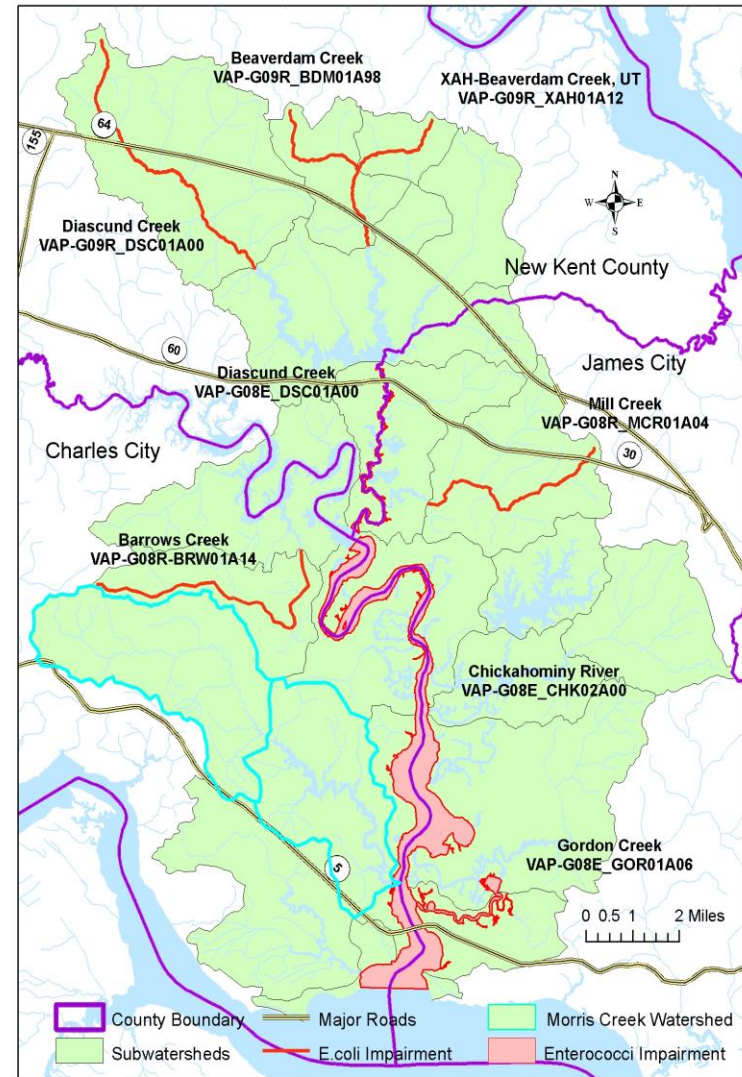
$$\text{Reduction} = (\text{current load} - \text{TMDL}) / \text{current load} \times 100\%$$

Overview of TMDL Process



Why do we need to improve water quality?

- Chickahominy River and seven Creeks are Impaired for elevated bacteria levels
- Morris Creek bacteria TMDL was completed in 2009. The results (source, current loading, and TMDL) will be used by this study



Diascund Creek



Beaverdam Creek



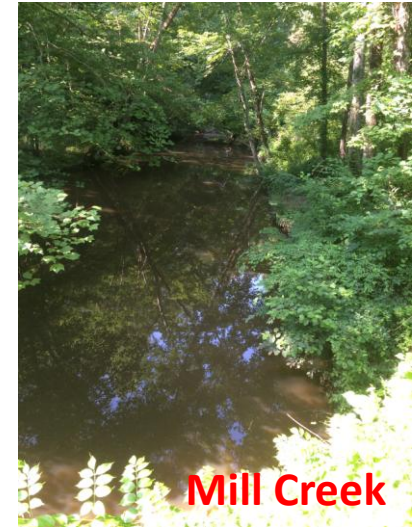
Diascund Creek



Beaverdam Creek



Mill Creek



Barrows Creek



Enterococci Impaired Waters

Stream and Assessment Unit	Impairment Description	Listing Date	County	Designated Uses
Chickahominy River G08E-04-BAC VAP- G08E_CHK02A00	The Chickahominy River from the confluence with Diascund Creek downstream to the James River. (5.92mi ²)	2006	Charles City & James City	Recreation
Diascund Creek G08E-03-BAC VAP- G08E_DSC01A00	Diascund Creek from the Diascund Reservoir dam to the mouth at the Chickahominy River. (0.27 mi ²)	2010	James City & New Kent	
Gordon Creek G08E-05-BAC VAP- G08E_GOR01A06	Tidal limit to mouth (0.2 mi ²)	2012	James City	

E. coli Impaired Waters

Stream Name and Assessment Unit	Impairment Description	Listing Date	County	Designated Use
Beaverdam Creek G09R-01-BAC VAP-G09R_BDM01A98	Beaverdam Creek from its headwaters to the upstream limit of Diascund Reservoir. (4.34mi)	2012	New Kent	Recreation
XAH-Beaverdam Creek, UT G09R-06-BAC VAP-G09R_XAH01A12	Headwaters to mouth at Beaverdam Creek. (2.23mi)	2012		
Diascund Creek G09R-02-BAC VAP-G09R_DSC01A00	Diascund Creek from its headwaters to the upstream limit of Diascund Creek Reservoir. (6.88mi)	2008		
Mill Creek G08R-02-BAC VAP-G08R_MCR01A04	Mill Creek from its headwaters downstream to its tidal limit. (4.81mi)	2004	James City	
Barrows Creek G08R-05-BAC VAP-G08R-BRW01A14	Headwaters to tidal limit. (6.93mi)	2014	Charles City	

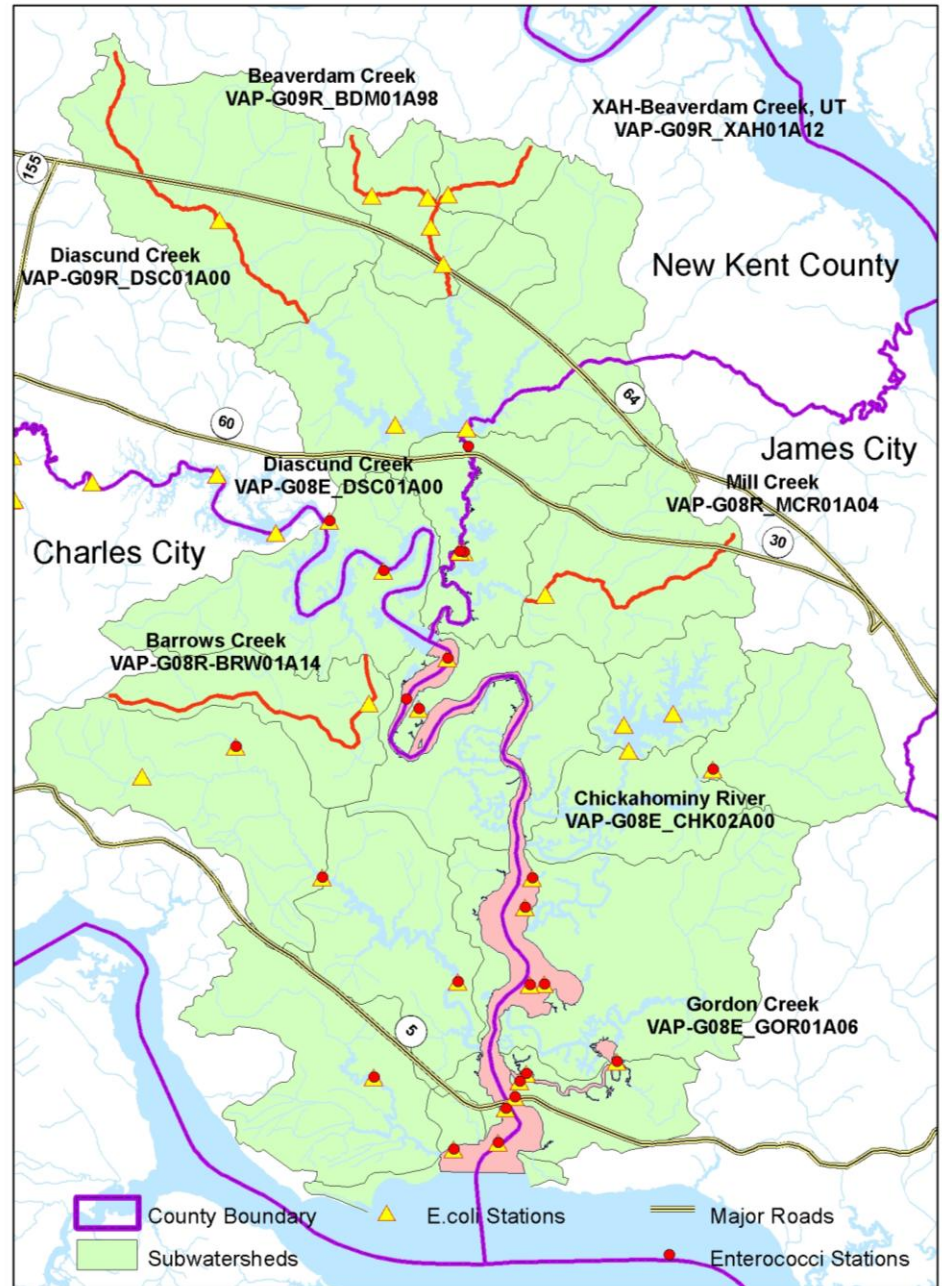
Water Quality Criteria

Use	Indicator Bacteria	Criteria
Recreation	<i>E. Coli</i> (freshwater)	Geometric Mean 126 counts/100ml * Single Sample Maximum 235 counts/100ml
	Enterococci (transition & salt water)	Geometric Mean 35 counts/100ml * Single Sample Maximum 104 counts/100ml

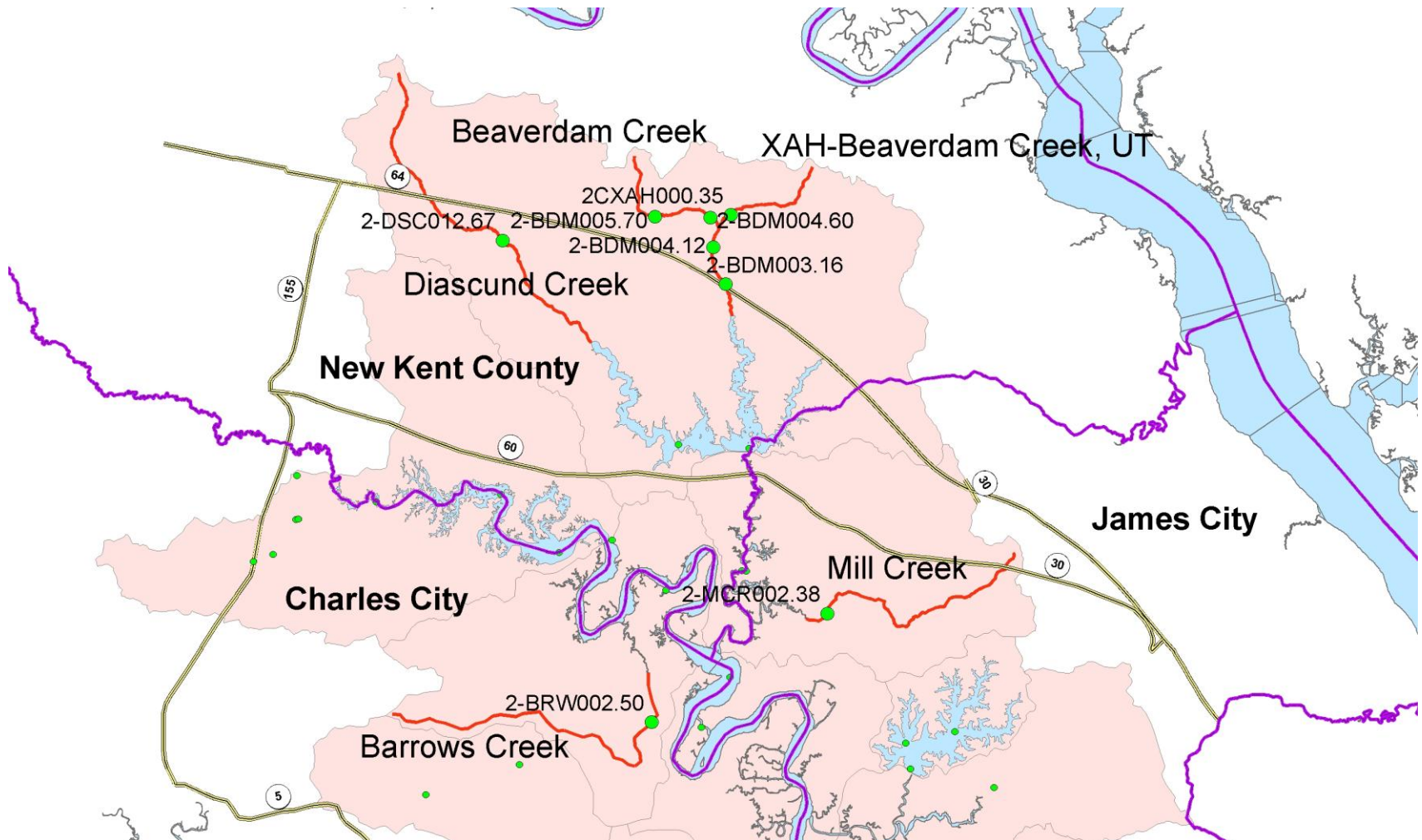
- *If there are insufficient data to calculate monthly geometric means in freshwater, no more than 10% of the total samples in the assessment period shall exceed 235 E.coli counts/100 ml .*

*** If there are insufficient data to calculate monthly geometric means in transition and saltwater, no more than 10% of the total samples in the assessment period shall exceed enterococci 104 counts/100 ml.*

Observation Stations



E. coli Observation Stations



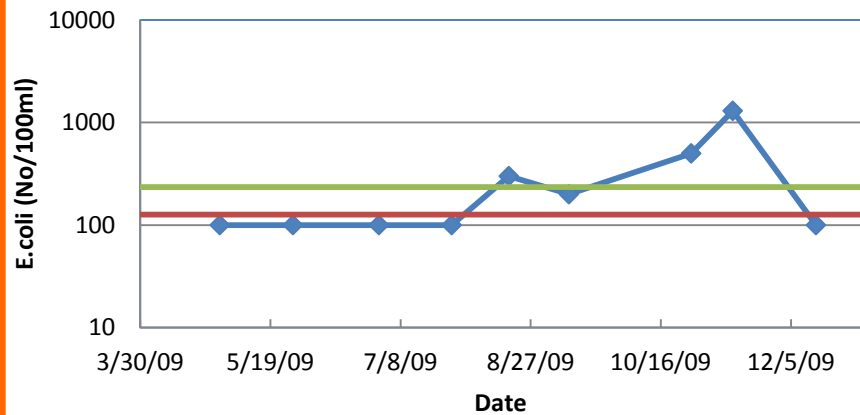
E. Coli Data Statistics

Station Id	Stream Name	Count	Average (#/100ml)	Standard Deviation	Minimum	Maximum	Monitoring Period
2-BDM003.16	Beaverdam Creek	9	311	395	100	1300	4/29/2009-12/14/2009
2-BDM004.12	Beaverdam Creek	20	208	362	1	1700	1/4/2007-12/14/2009
2-BDM004.60	Beaverdam Creek	9	267	218	100	700	4/29/2009-12/14/2009
2-BDM005.70	Beaverdam Creek	9	500	394	100	1000	4/29/2009-12/14/2009
2-BRW002.50	Barrows Creek	12	444	684	25	2000	1/10/2011-12/10/2012
2CXA000.35	Beaverdam Creek, UT	6	367	513	100	1400	4/29/2009-12/14/2009
2-DSC012.67	Diascund Creek	31	168	445	3	2500	7/2/2003-8/6/2004
2-MCR002.38	Mill Creek	24	271	338	25	1450	2/9/2009-12/9/2013

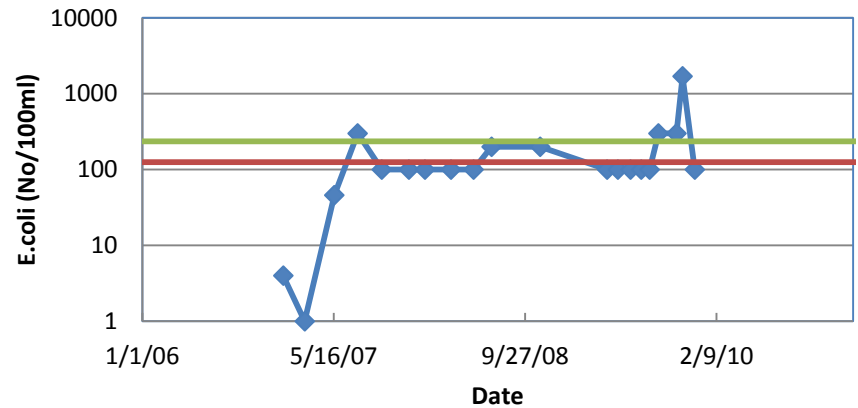
E. coli Data Time Series

Beaverdam Creek

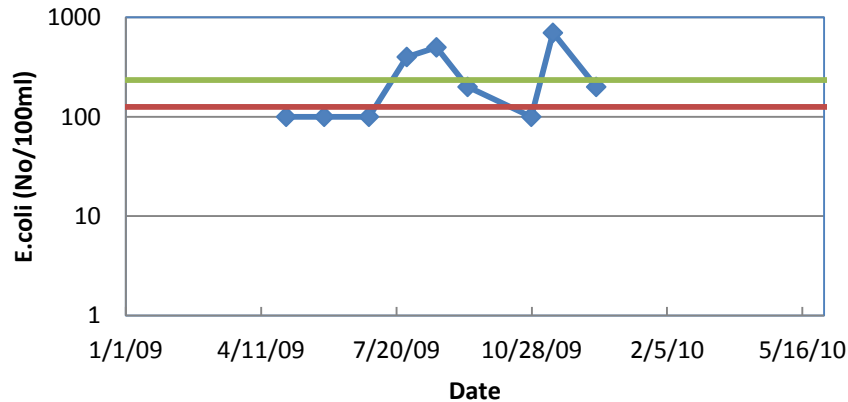
2-BDM003.16



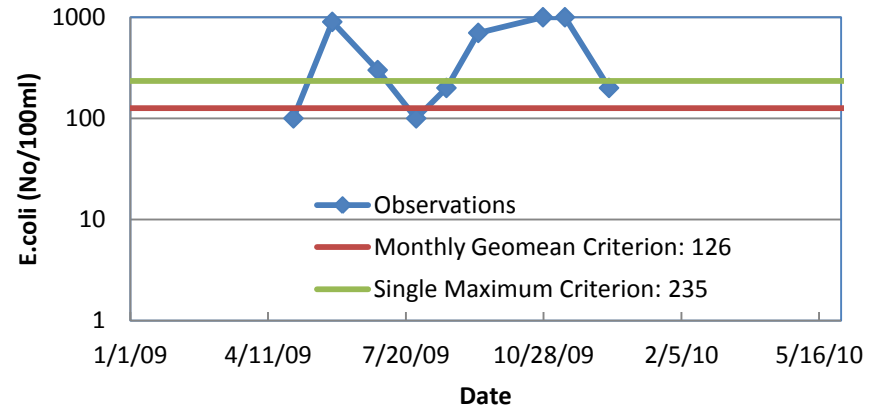
2-BDM004.12

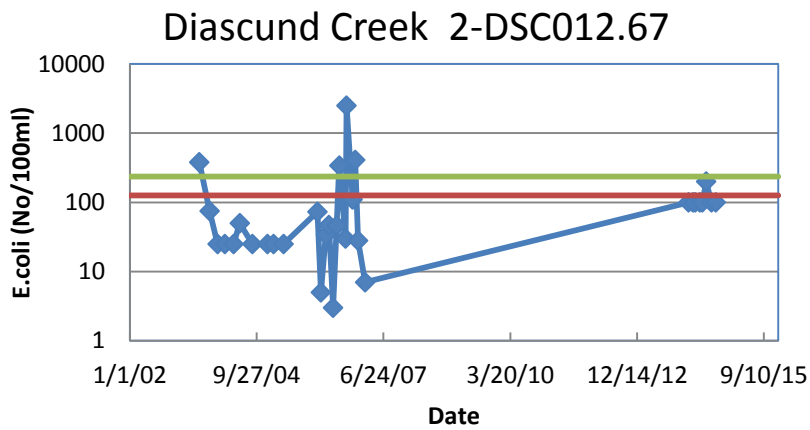
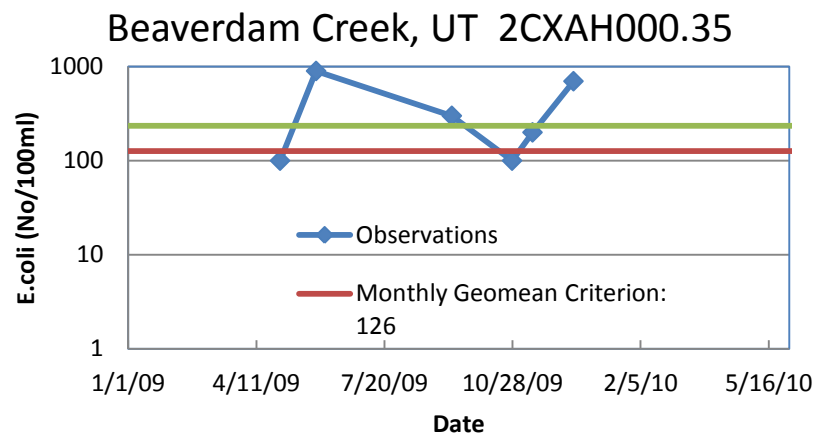


2-BDM004.60

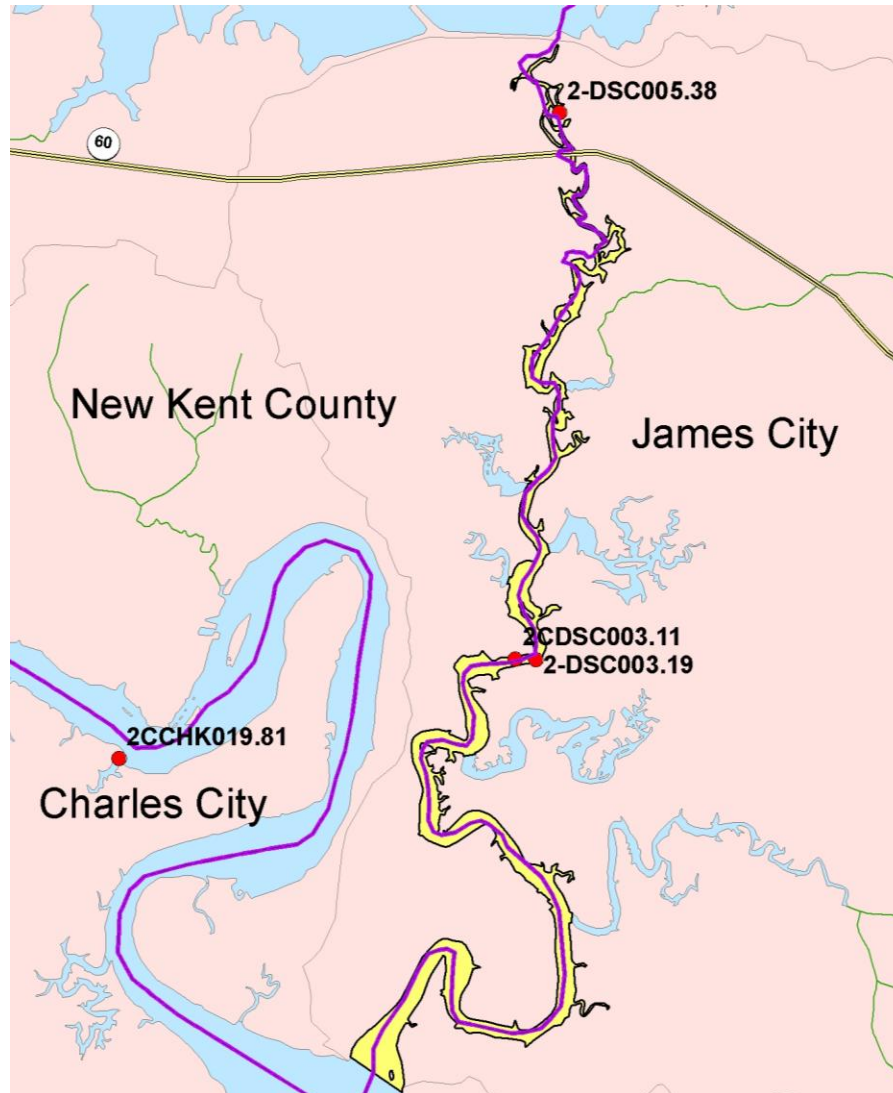


2-BDM005.70



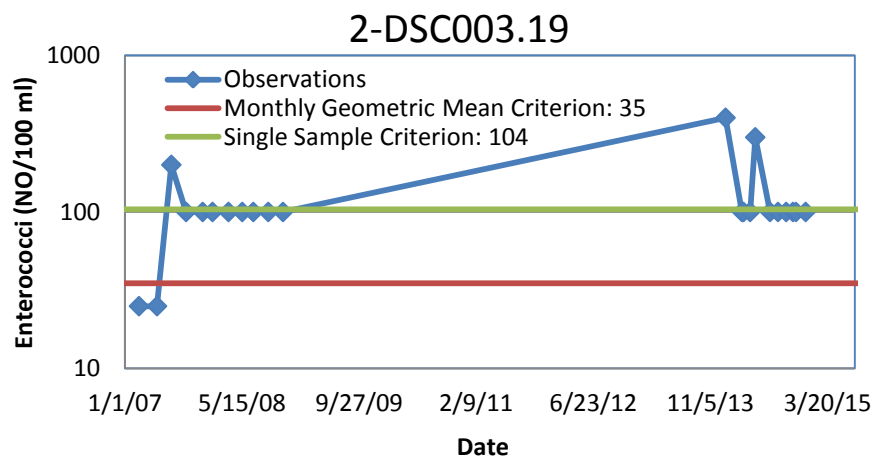


Enterococci Observation Stations- Diascund Creek

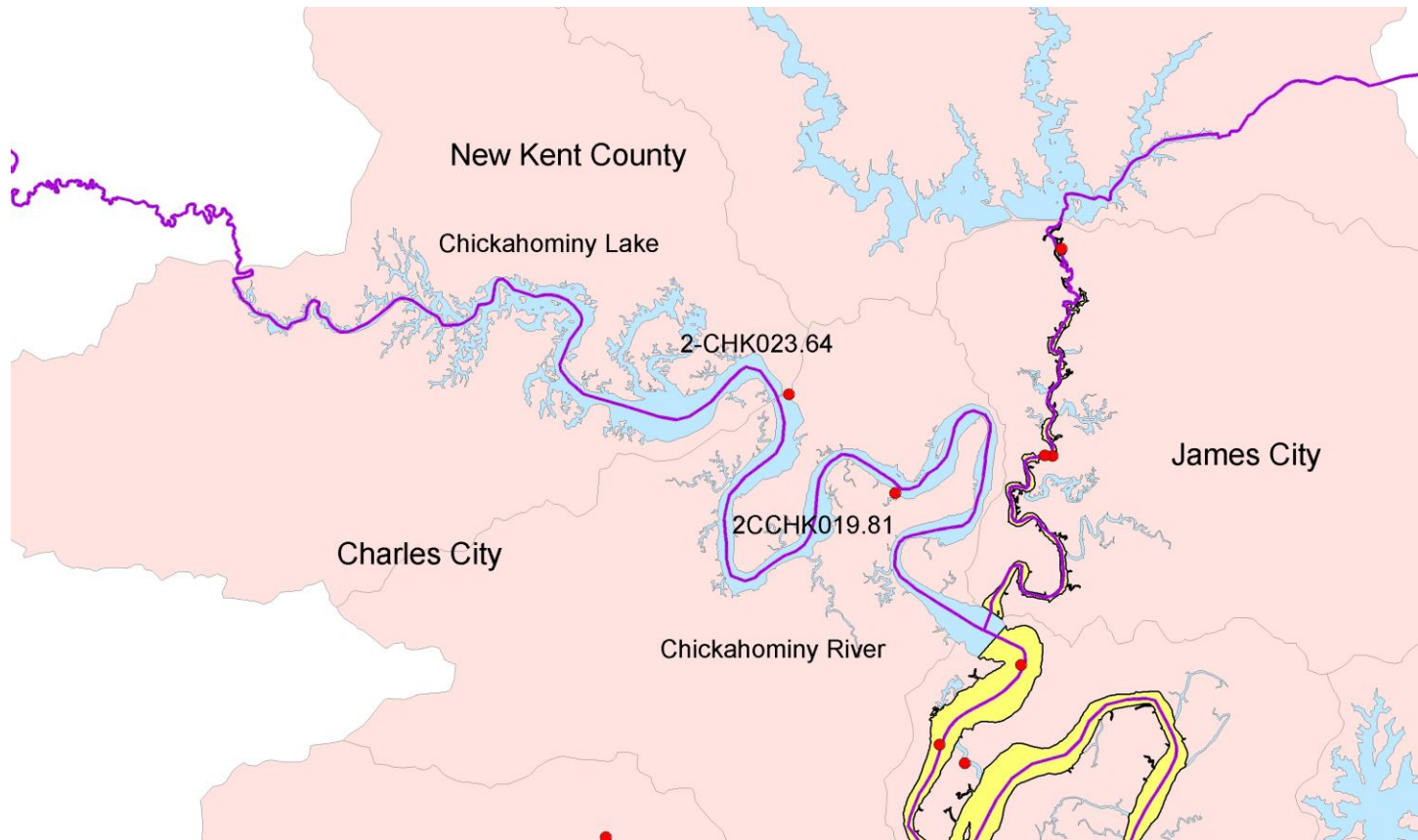


Enterococci Observation Stations- Diascund Creek

Station Id	Count	Average (#/100mL)	Standard Deviation	Minimum	Maximum	Monitoring Period
2CDSC003.11	1	10		10	10	6/27/2011
2-DSC003.19	22	120	82	25	400	3/1/2007-12/16/2014
2-DSC005.38	12	233	257	100	1000	1/13/2014-12/16/2014

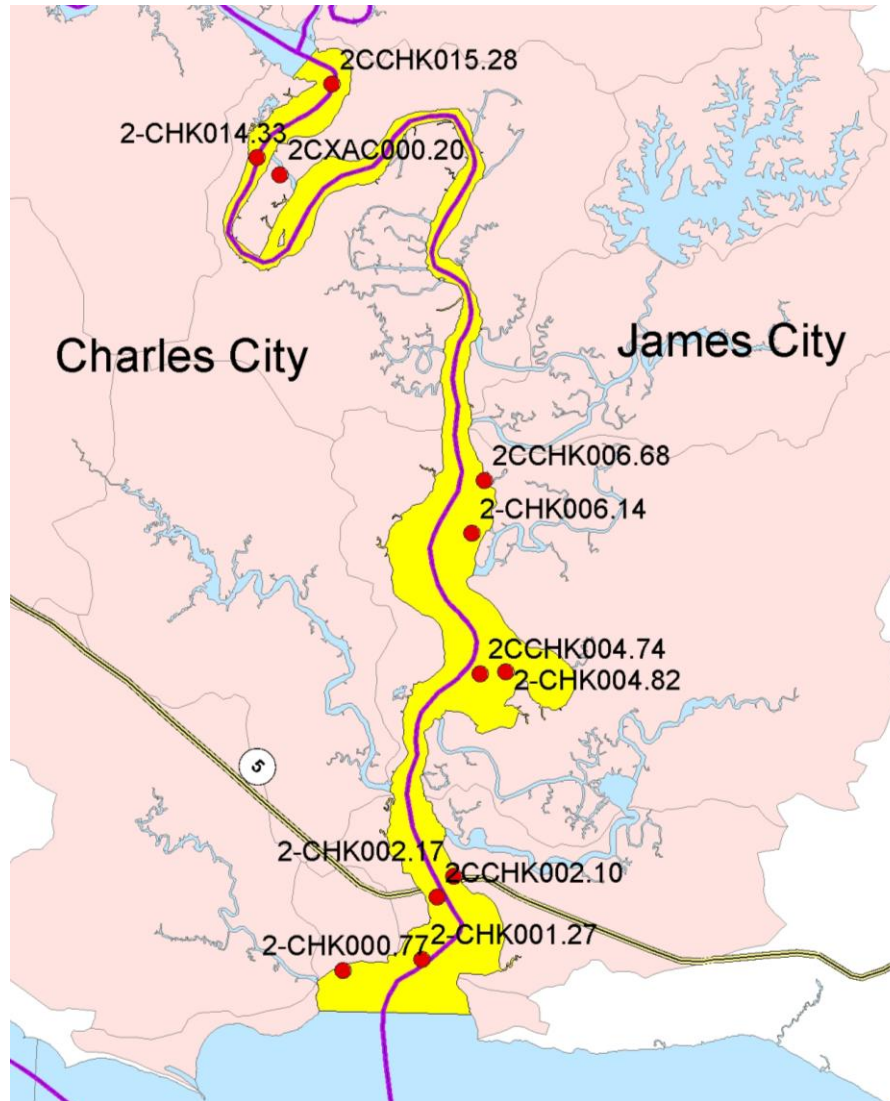


Upstream Enterococci Data



Station Id	Count	Average	Standard Deviation	Minimum	Maximum	Monitoring Period
2-CHK023.64	60	50	45	10	200	7/2/2003-4/2/2015
2CCHK019.81	3	60	17	40	70	7/25/2012-8/7/2013

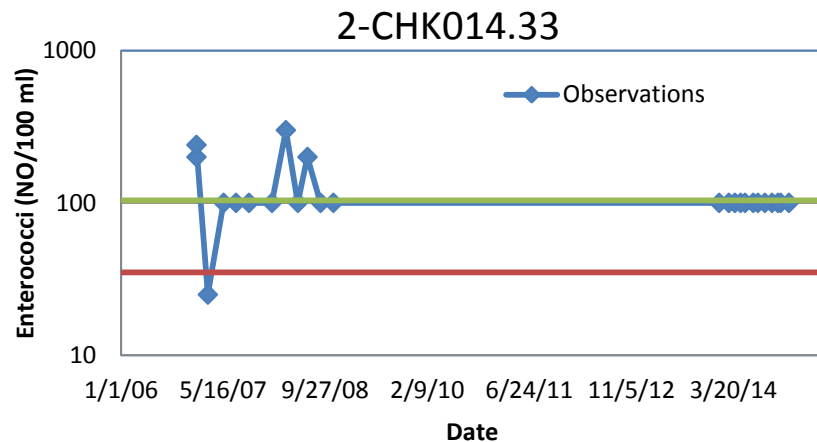
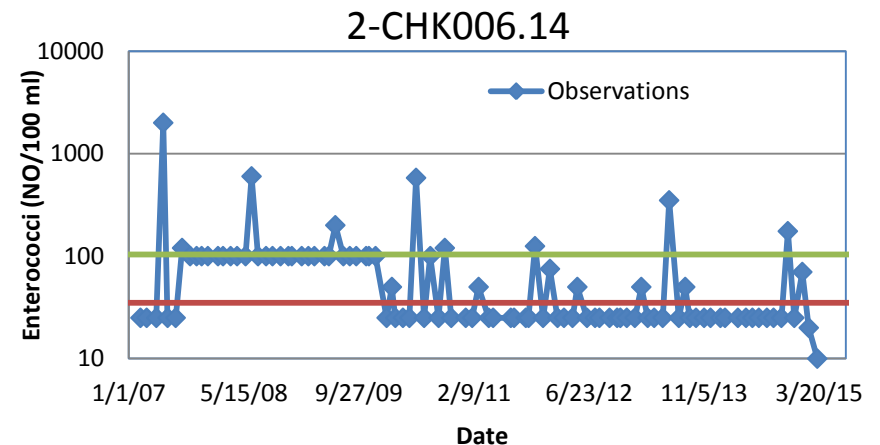
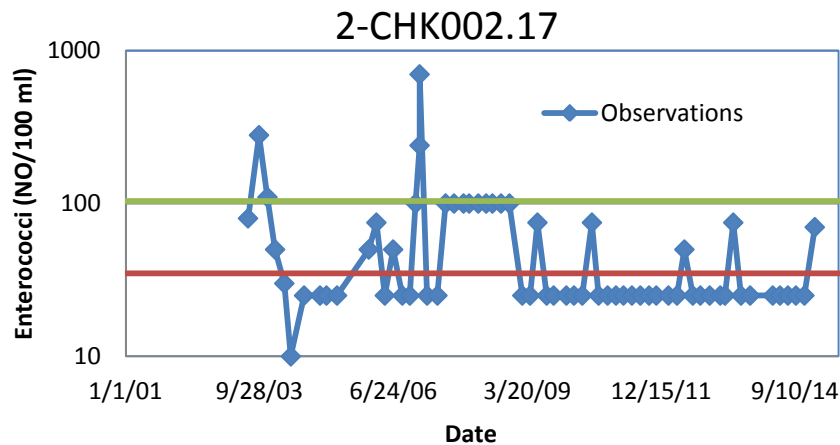
Enterococci Observation Stations- Chickahominy River



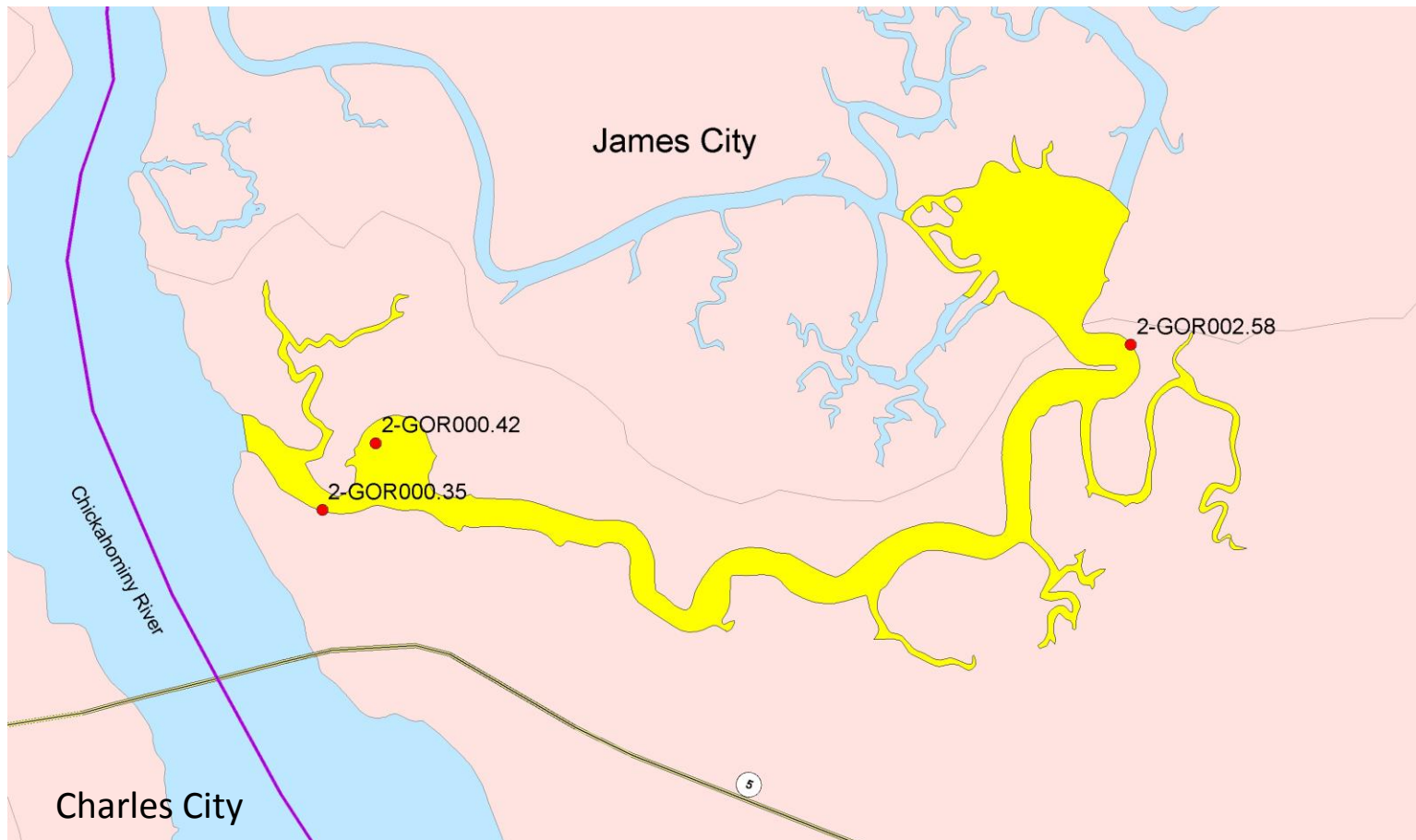
Enterococci Observation Stations- Chickahominy River

Stream Name	Station Id	Count	Average (#/100mL)	Standard Deviation	Minimum	Maximum	Monitoring Period
Chickahominy River	2CCHK002.10	1	50		50	50	7/16/2008
	2CCHK004.74	1	130		130	130	6/21/11
	2CCHK006.68	1	10		10	10	7/7/14
	2CCHK015.28	1	20		20	20	7/1/13
	2CXAC000.20	1	70		70	70	7/21/08
	2-CHK000.77	1	30		30	30	7/10/07
	2-CHK001.27	1	10		10	10	8/12/04
	2-CHK002.17	64	62	94	10	700	7/2/2003- 2/3/2015
	2-CHK004.82	1	10		10	10	7/10/2007
	2-CHK006.14	95	91	218	10	2000	2/20/2007- 3/12/2015
	2-CHK014.33	24	119	58	25	300	1/4/2007- 12/16/2014

Enterococci Observation Stations- Chickahominy River

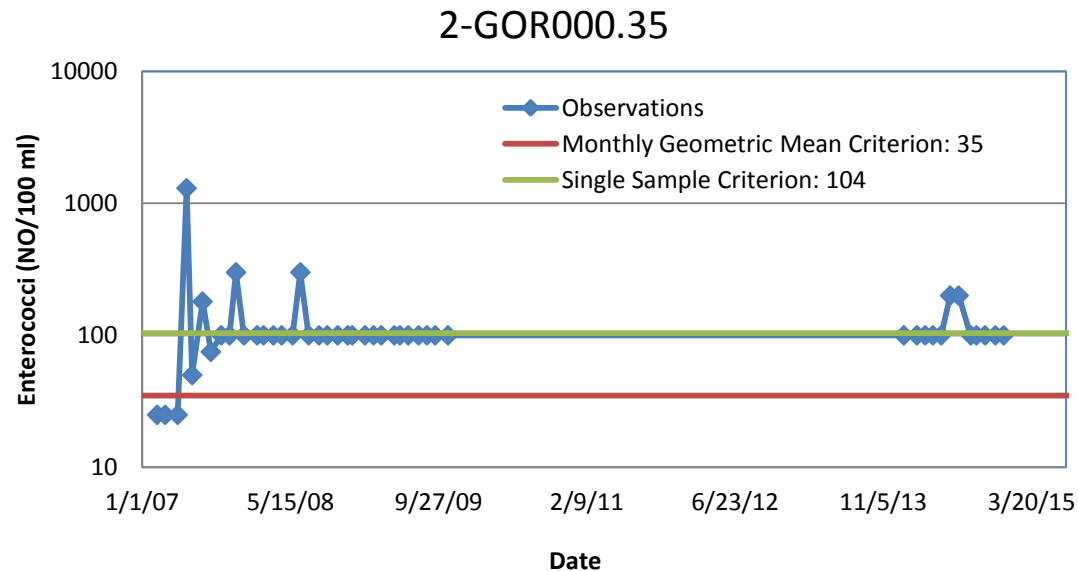


Enterococci Observation Stations- Gordon Creek



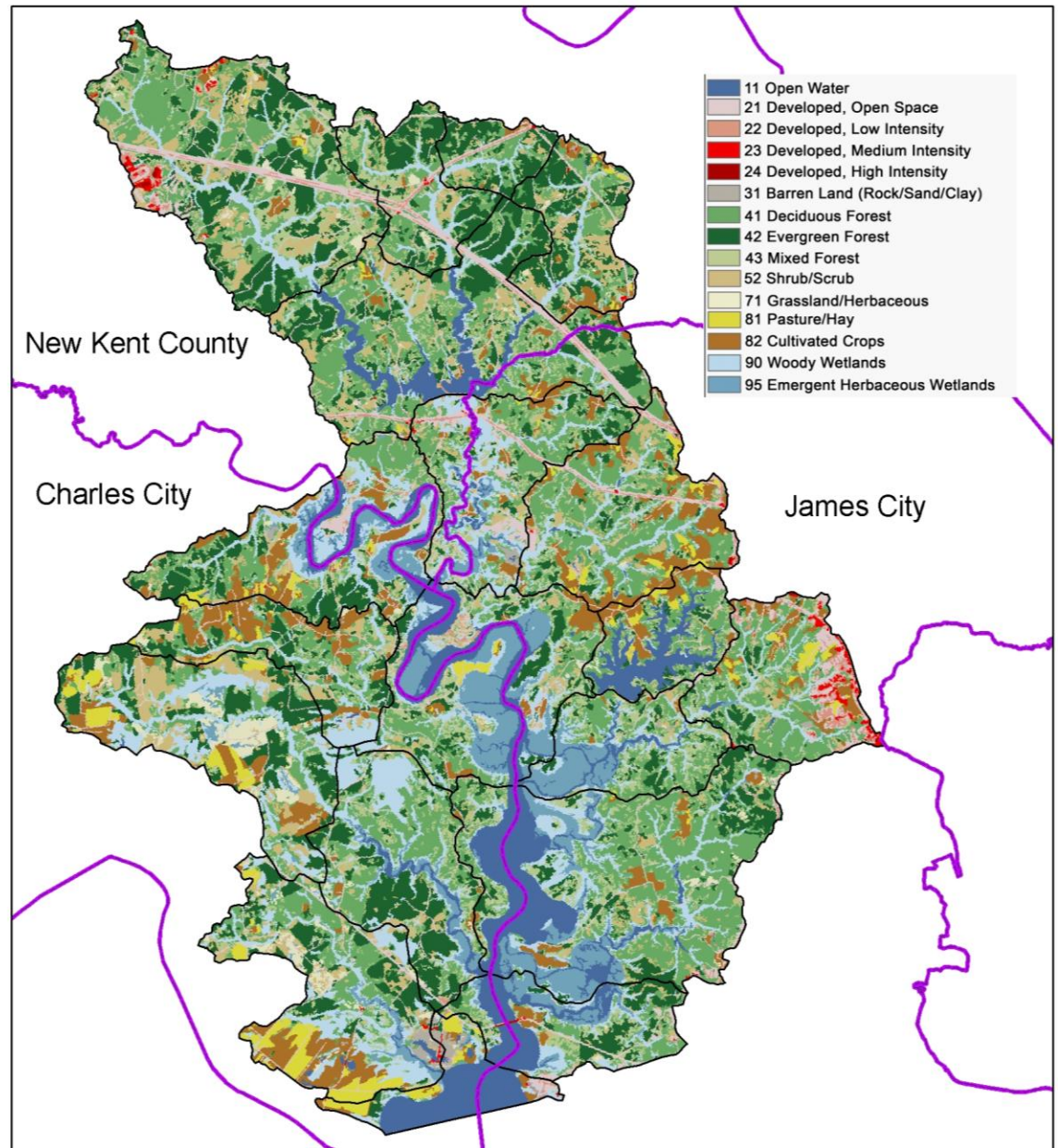
Enterococci Observation Stations- Gordon Creek

Stream Name	Station Id	Count	Average	Standard Deviation	Minimum	Maximum	Monitoring Period
Gordon Creek	2-GOR000.35	45	135	185	25	1300	2/20/2007-12/16/2014
	2-GOR000.42	1	10		10	10	8/12/04
	2-GOR002.58	1	80		80	80	8/27/03

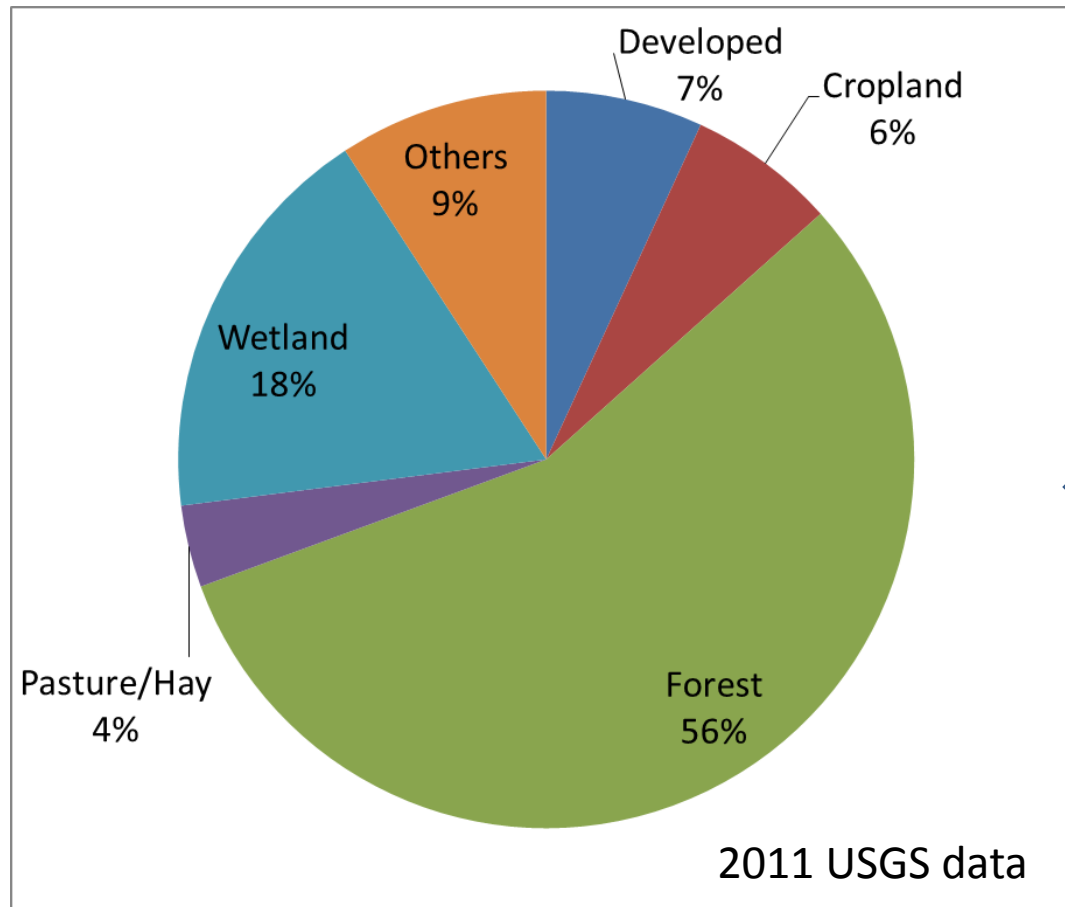


Land Use

(USGS NLCD
2011 data)



Land Use Percentages



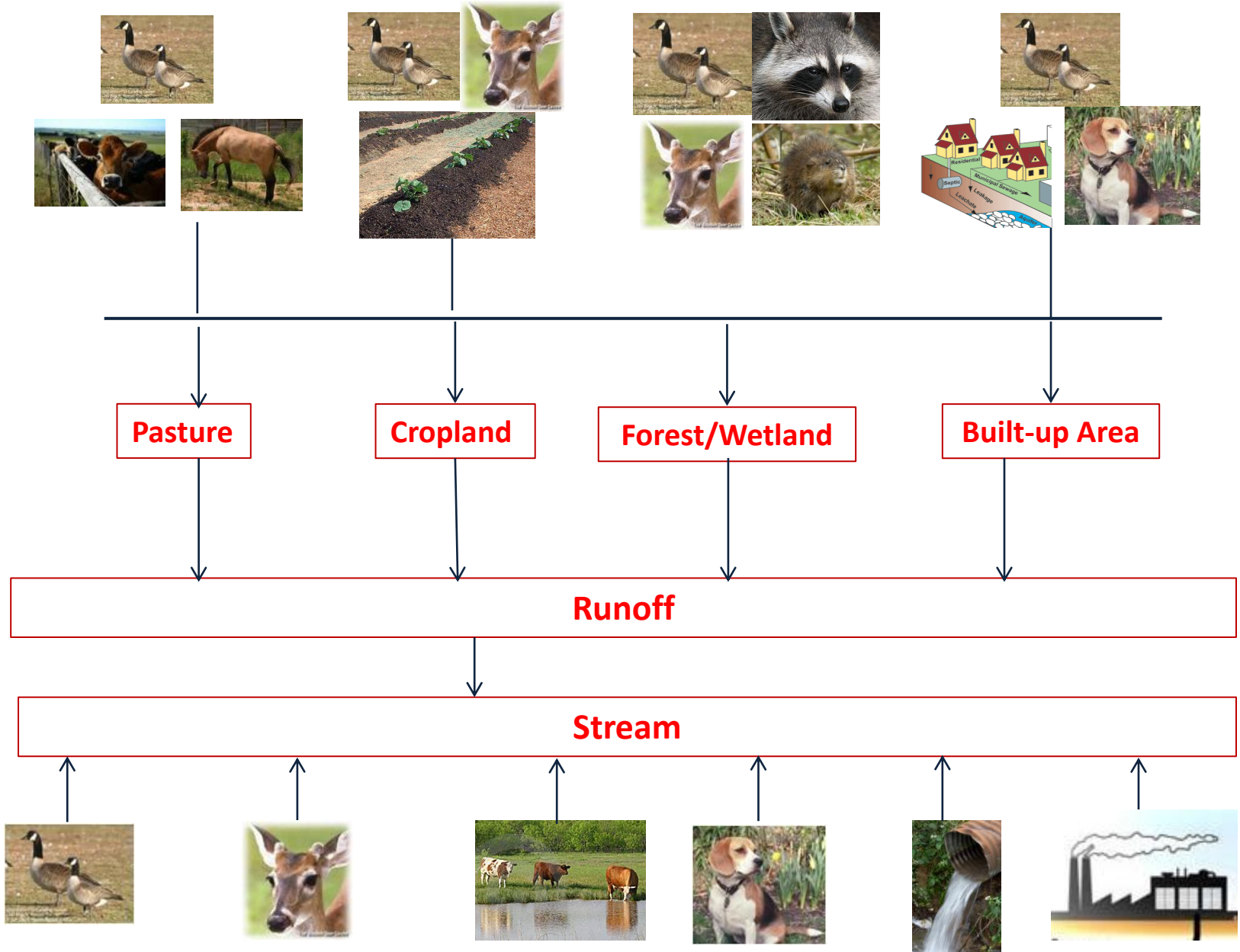
Undeveloped = 74%
Ag. = 10 %

- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands

Procedures of Pollutant Source Assessment

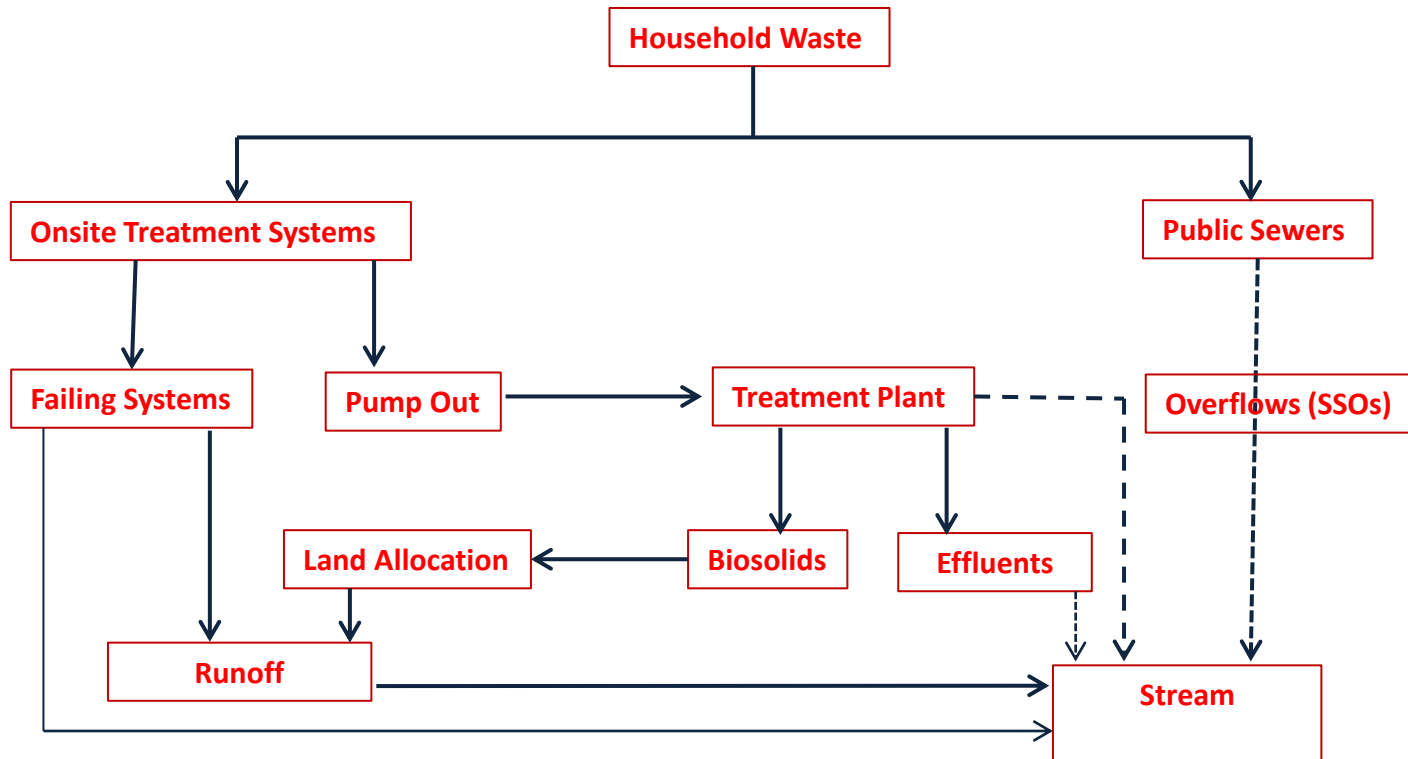
- Sources
 - Point Source: any discernible, confined and discrete conveyance, from which pollutants are or may be discharged.
 - Non-point Source: any source of water pollution that does not meet the legal definition of "point source".
 - Agricultural
 - Livestock
 - Humans
 - Pets
 - Wildlife
- Approach
 - GIS land use data (land use, population, pets, septic systems)
 - Field survey
 - Census of Agriculture data
 - Wildlife survey data (animal density, animal habitat)
 - Public inputs
 - Public meeting
 - Interview with local people

Potential Sources



Source Assessment

Human Contribution



Mill Creek as An Example-Septic System



Watershed	Population	Number of Households	Failure Rate	Failing Septic Systems
Mill Creek	1026	421	2.5%	11

Watershed	Septic Flow (gal/day)	FC Concentration (counts/100 ml)	FC Rate (counts/hour)
Mill Creek	179,550	1.00E+04	2.83E+09

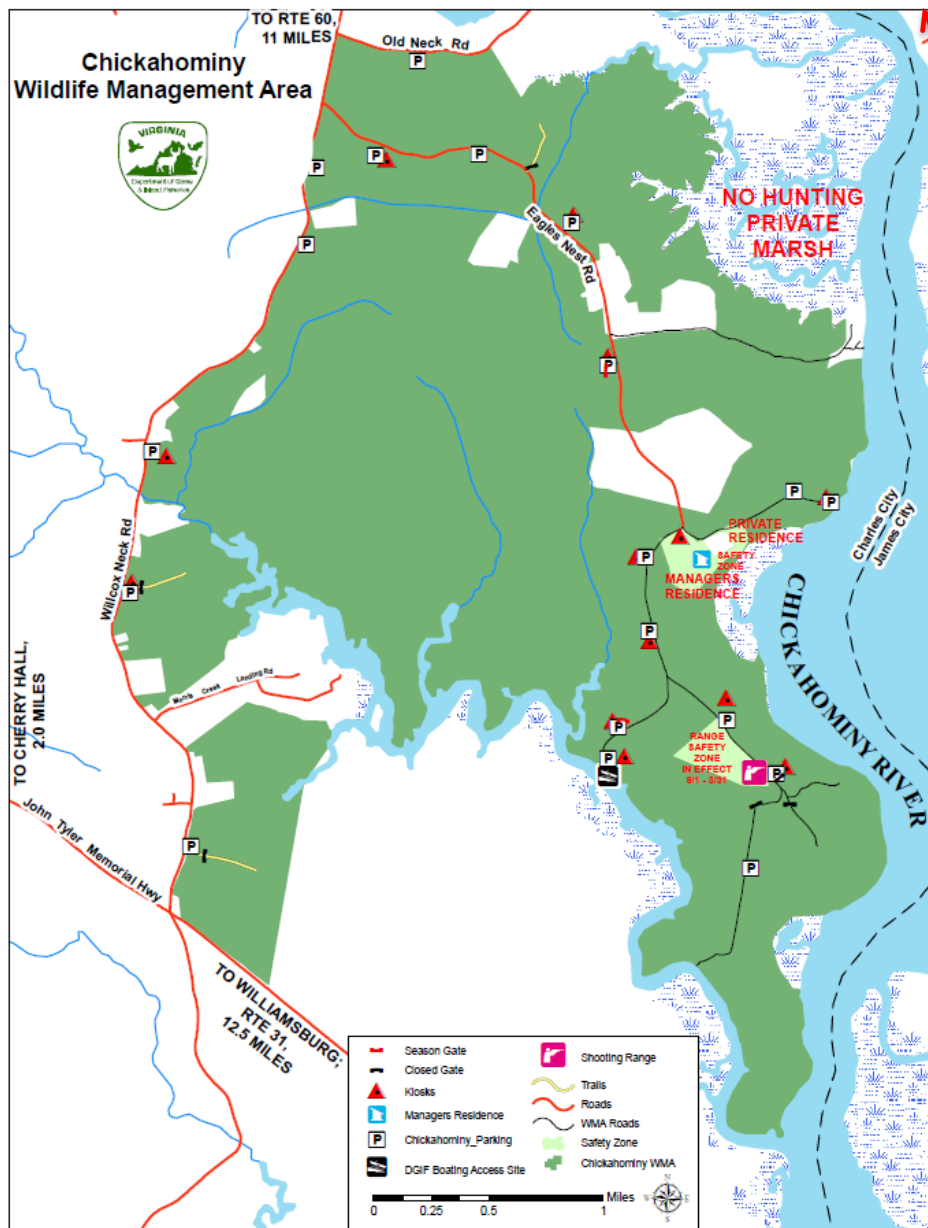
Statewide Wildlife Habitat (Statewide Average values)

Wildlife Densities		
Wildlife type	Population Density	Habitat Requirements
Deer	0.047 animals/acre	Entire watershed, except open water and urban development
Raccoon	0.078 animals/acre	Forest and Wetland within 600 feet of streams and ponds
Raccoon	0.016 animals/acre	Upland Forest
Muskrat	50/mile	Streams and Rivers
Nutria	18.5/mile	Streams and Rivers
Residential Geese	0.02 animals/acre	Entire Watershed
Waterfowl	0.002 animals/acre	Entire Watershed

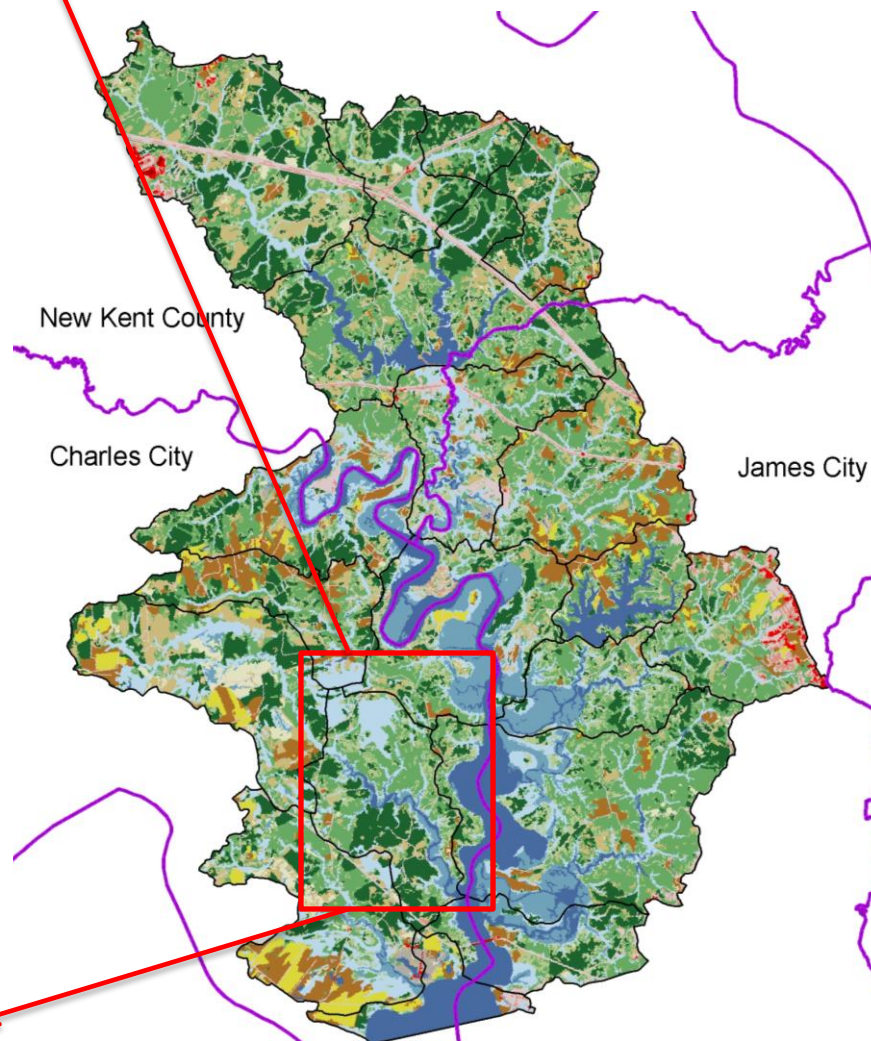
Mill Creek as An Example-Wildlife

Wildlife type	Density	Habitat Requirements	Fecal Coliform Production (count/animal/day)
Deer	?	Entire watershed, except open water and urban development	500,000,000
Raccoon	?	Forest and Wetland within 600 feet of streams and ponds	125,000,000
Ducks	?	Forest and Wetland within 800 feet of streams and ponds	2,430,000,000
Geese	?	Forest and Wetland within 800 feet of streams and ponds	49,000,000,000
Other	?	Entire Watershed	

No wildlife density information in the watershed is available and we are contacting VA Dept. of Game and Inland Fisheries and counties for the numbers.



Location of Chickahominy Wildlife Management Area



Mill Creek as An Example-Livestock

- US Census of Agriculture provides livestock information for each county. However, no local information and location of the livestock were provided. Therefore the livestock numbers are allocated according to landuse areas.

Numbers	Beef Cattle	Pig	Milk Cattle	Chicken	Horse	Sheep	Other
Charles City	432	35	0	476	194	90	219
James City	230	33	165	926	389	5	33
New Kent County	699	20	12	1145	415	137	129

Source: US Census of Agriculture 2012

Area (m ²)	Built-Up	Cropland	Pastureland	Forest	Total
Charles City	20,598,300	51,584,400	40,415,400	257,262,300	369,860,400
James City	77,065,200	25,862,400	8,402,400	187,146,000	298,476,000
New Kent County	42,678,900	43,327,800	18,533,700	341,803,800	446,344,200

Source: USGS NLCD 2011

Mill Creek as An Example-Livestock

Livestock Density = Total Number of the Livestock/ Total Landuse Area of the Livestock

Density (Number/m ²)	Beef Cattle	Pigs	Milk Cattle	Chickens	Horses	Sheep	Other
Charles City	1.1E-05	9.5E-08	0.0E+00	1.3E-06	4.8E-06	2.2E-06	5.4E-06
James City	2.7E-05	1.1E-07	2.0E-05	3.1E-06	4.6E-05	6.0E-07	3.9E-06
New Kent County	3.8E-05	4.5E-08	6.5E-07	2.6E-06	2.2E-05	7.4E-06	7.0E-06

Livestock Of Mill Creek = Livestock Density * Total Landuse Area of the Livestock in Mill Creek

?

Watershed	Beef Cattle	Pigs	Milk Cattle	Chickens	Horses	Sheep	Other
Mill Creek	30	2	22	68	51	1	4

- The probable number of livestock estimated based on proportion of landuse needs to be verified. Some numbers are not manful. **We need your feedback. Any information is welcome !**

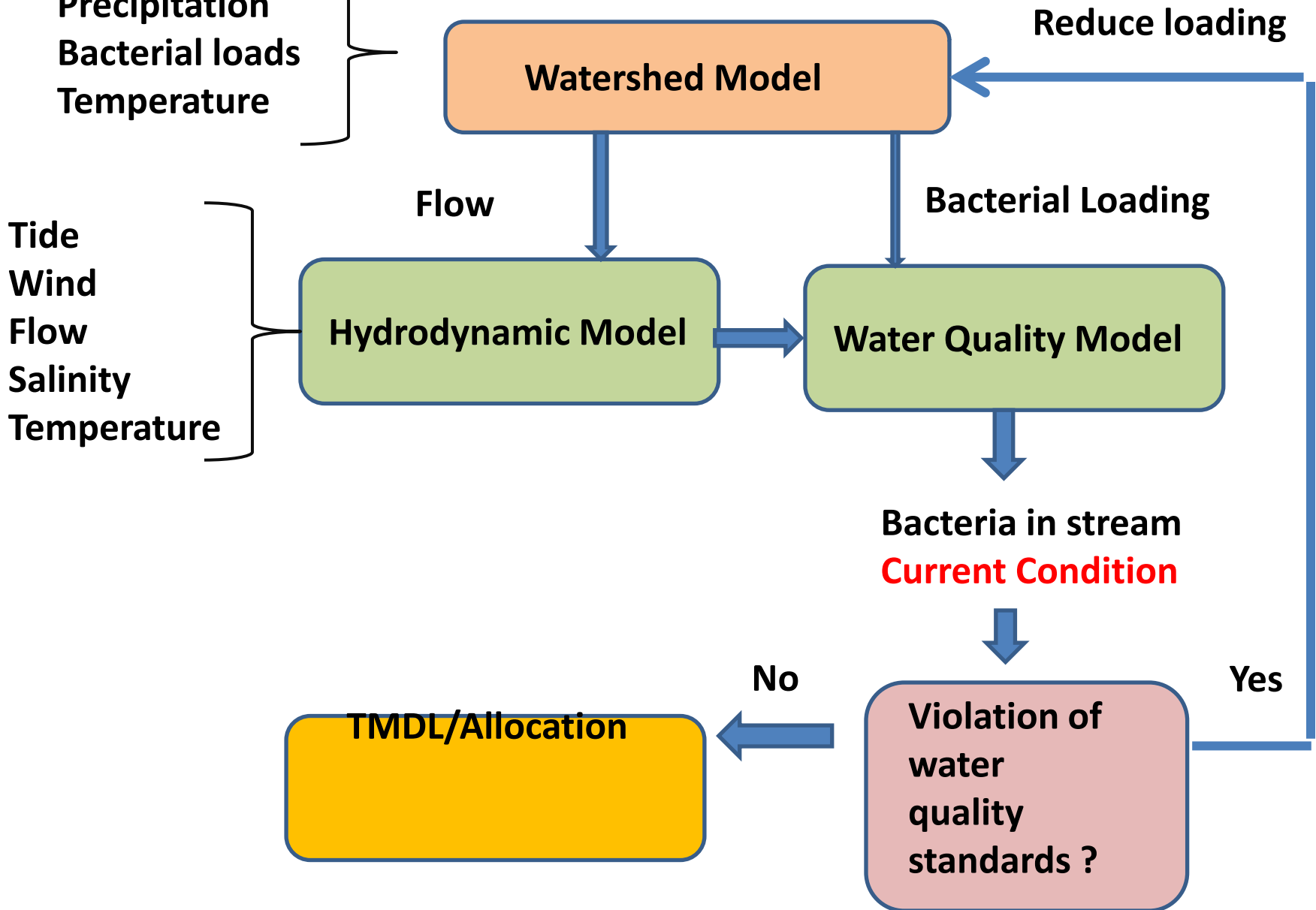
Modeling Approach

- Conduct source analysis
 - Estimate bacteria sources by each each sub-watershed.
 - Load will be grouped by locality/district
 - Use Loading Simulation Program C++ (LSPC) to simulate watershed processes: flow and bacteria
- Use 3D hydrodynamic fluid environmental computation code (EFDC)
 - Simulate bacteria transport and fate

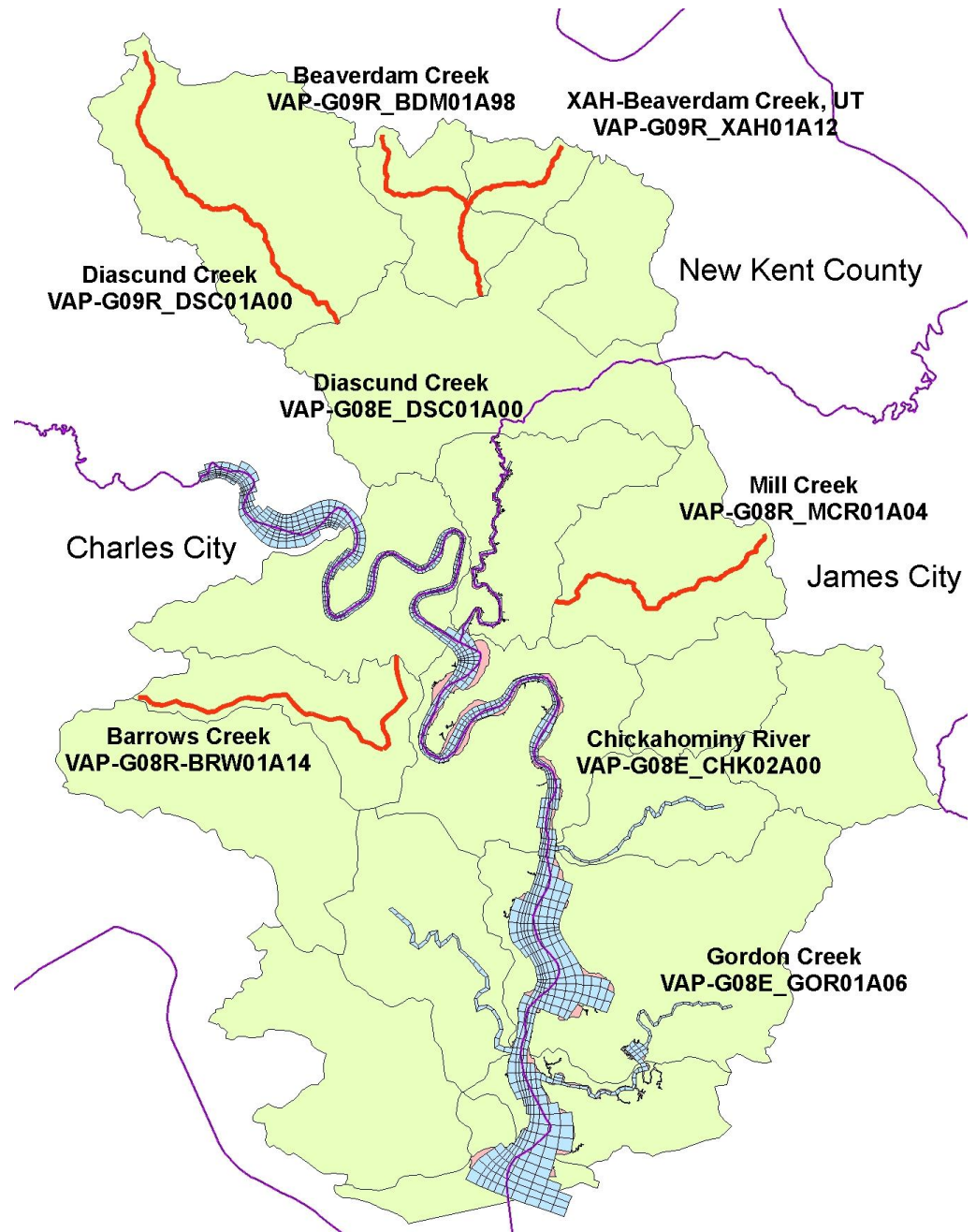
Model Simulation

- Watershed Segmentation
 - Simulation flow, loading using Loading Simulation Program C⁺⁺ (LSPC)
- Receiving water
 - grid generation
 - Simulate pollutant transport using Environmental Fluid Dynamic Computer Code (HEM3D/EFDC)
 - Simulate tide to generate boundary condition use SELFE model
- Both models are supported by USEPA

Modeling Approach



Watershed model segmentation and three- dimensional model grid



TMDL Development

- Source analysis
- Use linked watershed and in-stream modeling approach
- Develop watershed model
- Simulate daily bacteria/nutrients loadings from watershed
- Conduct watershed model calibration
- Discharge loads to in-stream model
- Use in-stream water quality model for simulating bacteria transport and DO dynamics
- Calibrate water quality model
- Compute allowable loads and determine load reduction

Public Participation Steps

- **First Public Meeting** (7/28/15)
 - Share and gather information!
 - Public comment period on initiation of TMDL study
- **(OPTIONAL) Technical Advisory Committee**
 - A TAC is convened during TMDL development for a group of interested stakeholders to discuss technical aspects of the TMDL.
 - Please let us know if you would like to participate! Meeting date/time will be based on the committee membership availability!
- **Final Public Meeting** (late 2015/early 2016)
 - Report TMDL results and post draft TMDL document on the DEQ website
 - Public comment period on draft TMDL

Questions, Comments, and Information

- Contribute your input and questions on bacteria sources
 - Wildlife density, livestock, failing septic facilities, etc.
- Loading estimation ?
- TMDL calculation ?
- Other questions/comments ?

This Presentation will be available at the DEQ web site at:

www.deq.virginia.gov

Public Comment Deadline: Thursday August 27, 2015

Send comments to:

Margaret Smigo (Margaret.Smigo@deq.virginia.gov)

Piedmont Regional TMDL Coordinator

Virginia Department of Environmental Quality

4949-A Cox Road, Glen Allen, VA 23060

Office: (804)527-5124 Fax: (804)527-5106

Thanks!

Permit #	Facility	Bacteria Limit Required by		Receiving Waterbody
		Permit Type	Permit?	
VAG110166	Branscome, Inc. - Charles City Concrete	General Permit	no	Chickahominy River, UT
VA0080233	Hideaway STP	Individual, Minor	yes	Chickahominy River
VAG840116	Hofmeyer Pit	General Permit	no	Tomahund Creek, UT
VA0085936	Mt. Zion - Rustic WTP	Individual, Minor	yes	Morris Creek
VAG840135	Sandy Point Sand & Gravel	General Permit	no	Tomahund Creek
VAG404	Single Family Home	General Permit	yes	Timber Swamp, UT
VAG404050	Single Family Home	General Permit	yes	Chickahominy River
VAG404144	Single Family Home	General Permit	yes	Chickahominy River
VAG404198	Single Family Home	General Permit	yes	Chickahominy River
VAG404152	Single Family Home	General Permit	yes	Chickahominy River
VAR040037	City of James City (MS4)	General Permit	yes	Various
VAR040115	Virginia Department of Transportation	General Permit	yes	Various